



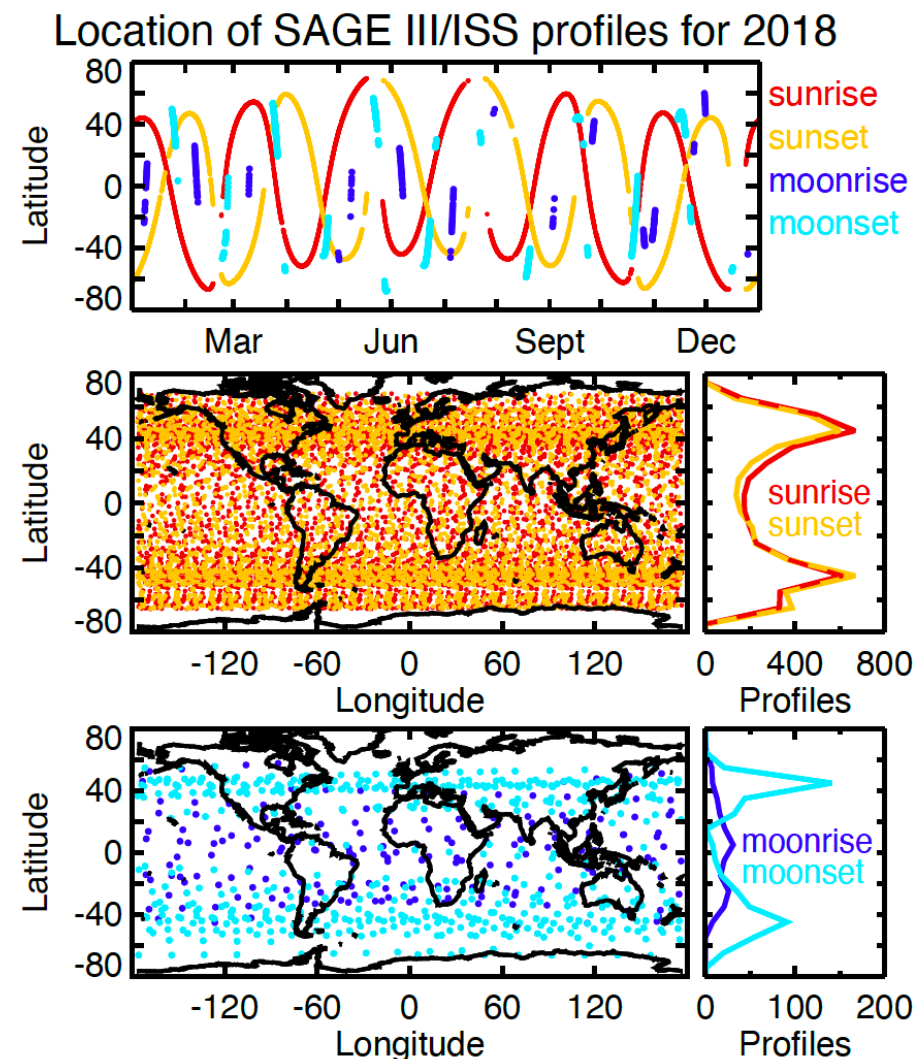
Developing a continuous ozone record through the SAGE and Aura satellite missions with NASA reanalysis products

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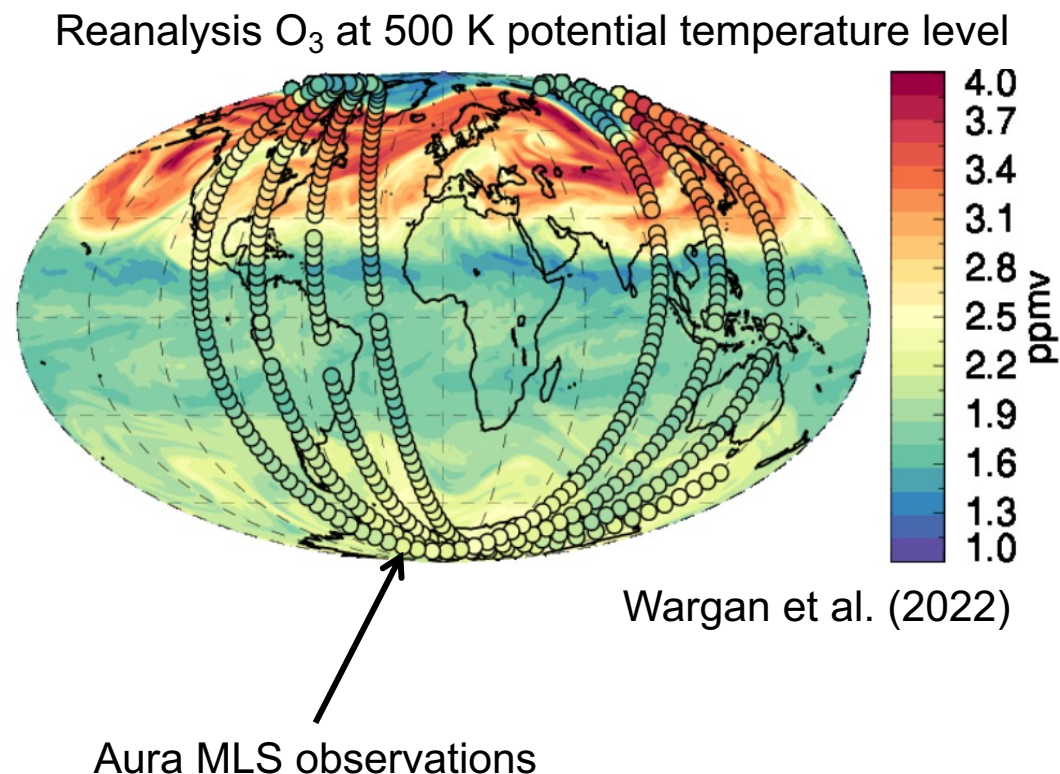
Background and Research Objectives

- Stratospheric Aerosol and Gas Experiment (SAGE) satellite instruments:
 - Reliable long-term record of stratospheric constituents
 - SAGE II (1984 – 2005)
 - SAGE III/M3M (2002 – 2005)
 - SAGE III/ISS (2017 – present)
- Propose connecting the gap in SAGE instruments using NASA reanalysis O_3
 - Account for changes in the reanalysis observing system



MERRA-2 Ozone Reanalysis

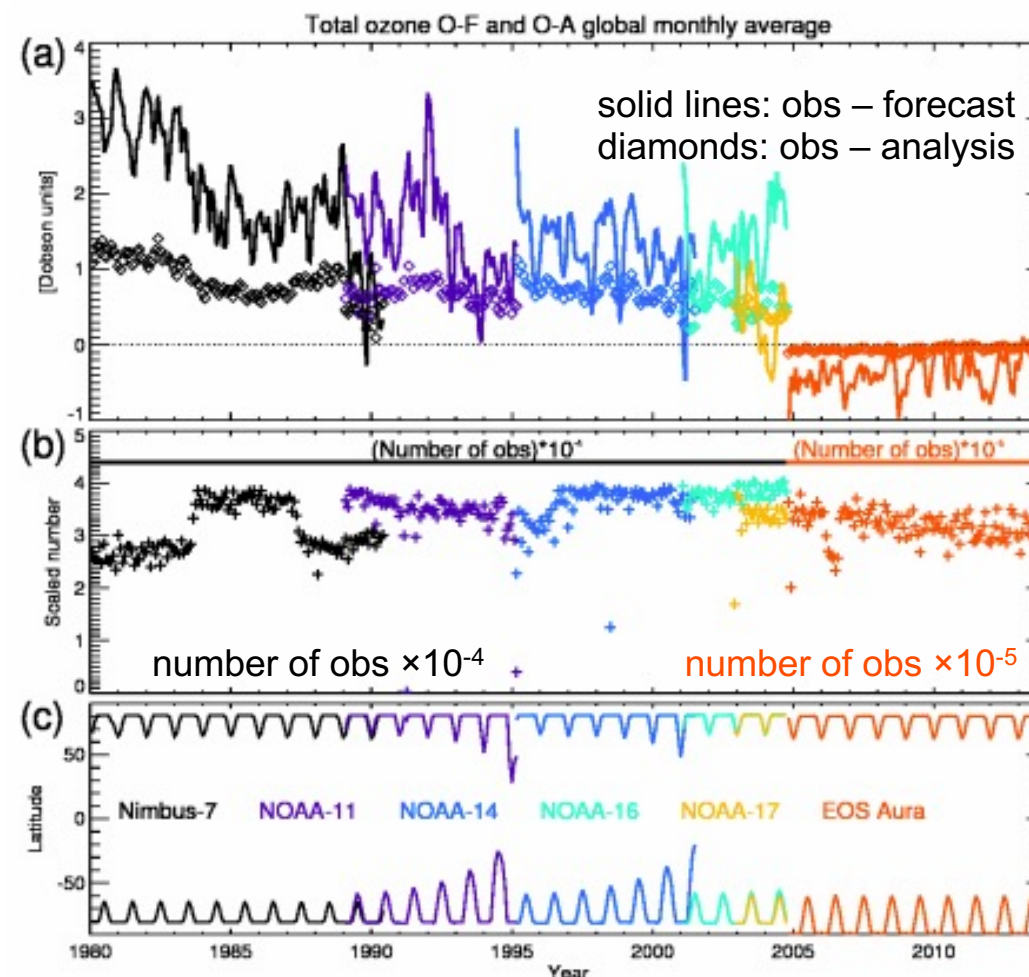
- Data assimilation produces global, vertically resolved fields by combining observations from multiple sensors
 - Less sensitive to sampling biases and instrumental drifts than merged observation datasets



MERRA-2: Modern-Era Retrospective Analysis for Research and Applications, version 2 (Gelaro et al., 2017)

MERRA-2 Ozone Reanalysis

- Data assimilation produces global, vertically resolved fields by combining observations from multiple sensors
 - Less sensitive to sampling biases and instrumental drifts than merged observation datasets
- Account for changes in the MERRA-2 observing system
 - Transition to Aura O₃ observations in 2004 (Wargan et al., 2018)
 - Investigate impact of meteorological updates in 1995 and 1998 using SAGE II

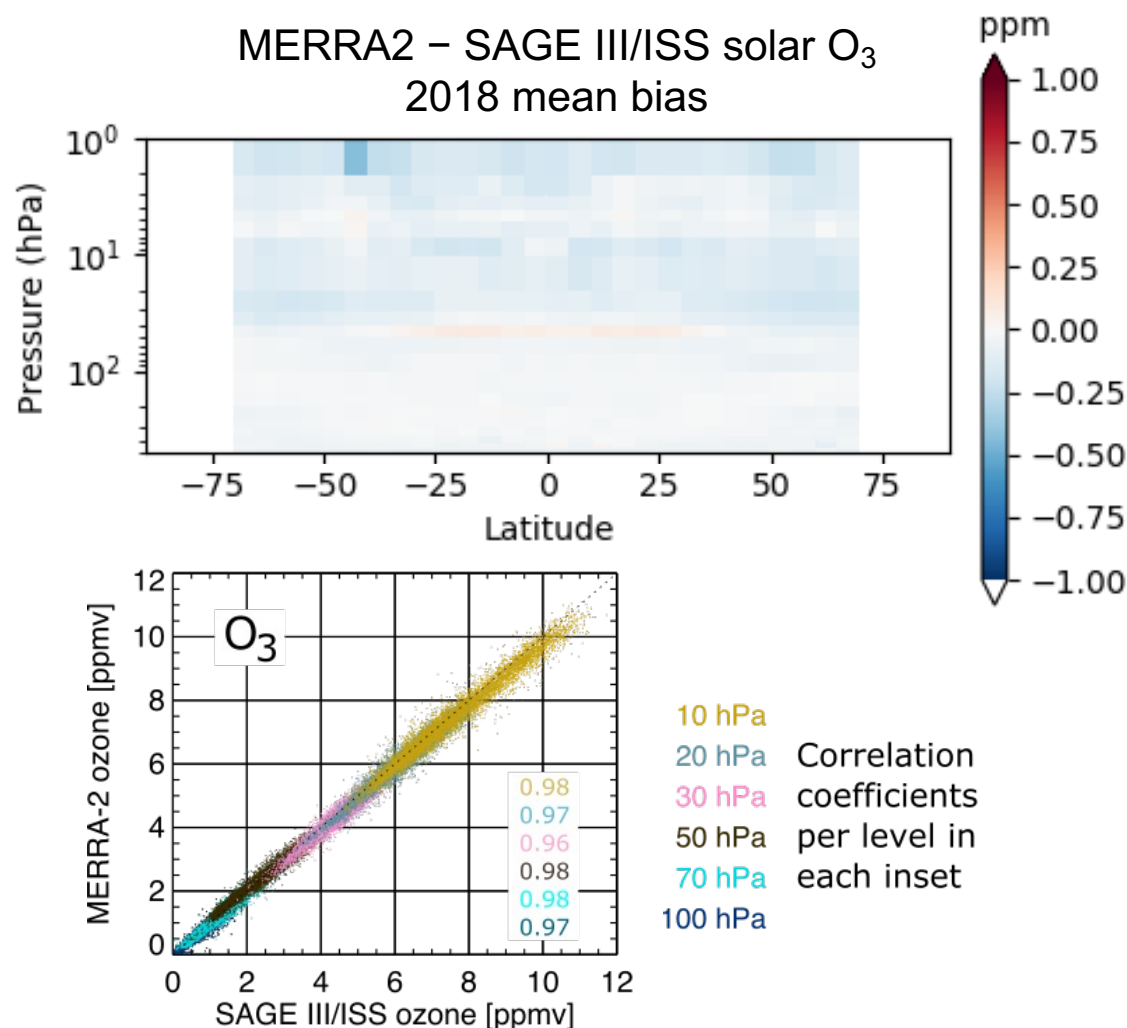


McCarthy et al. (2016)

MERRA-2: Modern-Era Retrospective Analysis for Research and Applications, version 2 (Gelaro et al., 2017)

MERRA-2 and SAGE Ozone

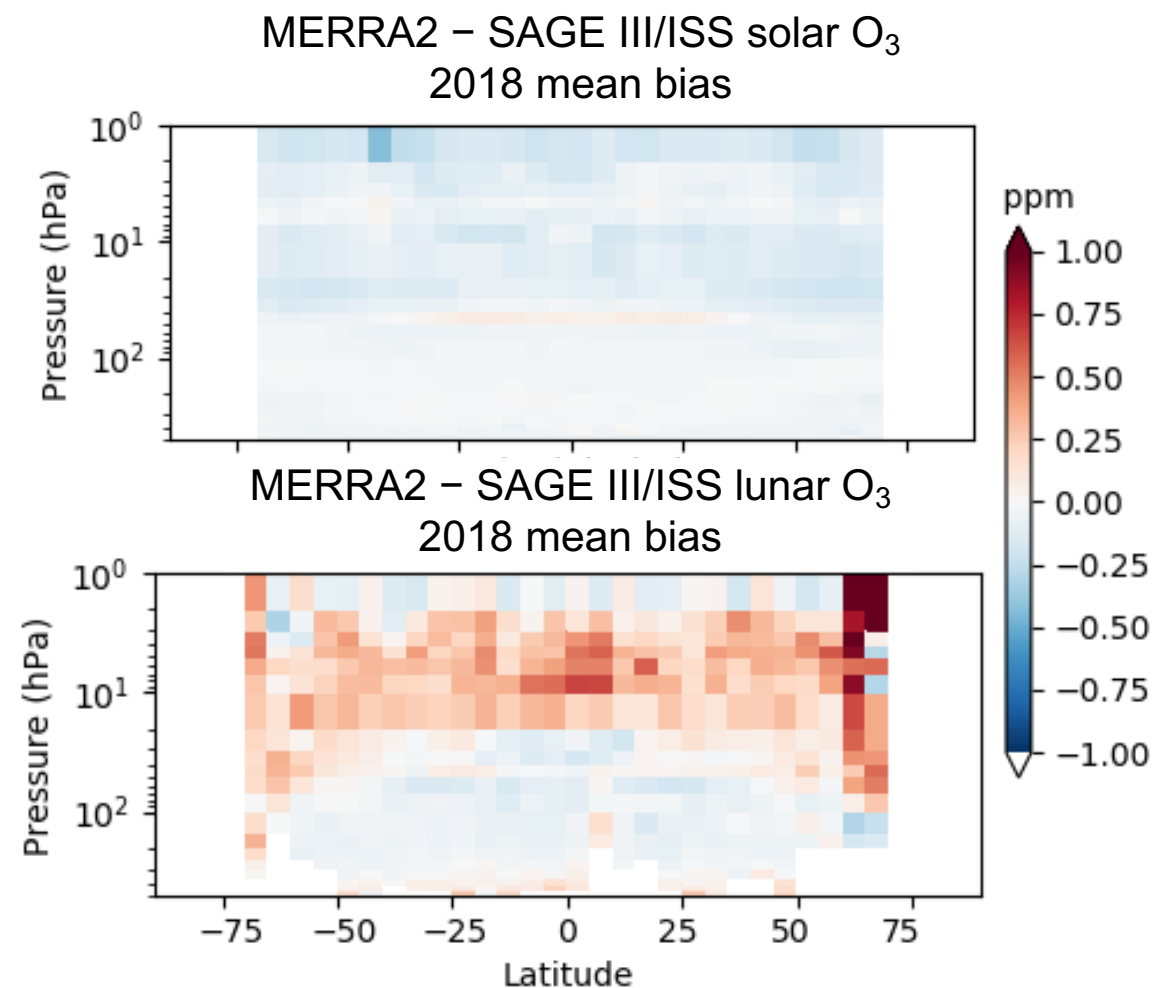
- MERRA-2 independently validated using SAGE measurements
 - Agreement with SAGE II improves in 2005 (Wargan et al., 2017)
 - Well correlated with a slight low bias with respect to SAGE III/ISS solar occultation measurements



MERRA-2: Modern-Era Retrospective Analysis for Research and Applications, version 2 (Gelaro et al., 2017)

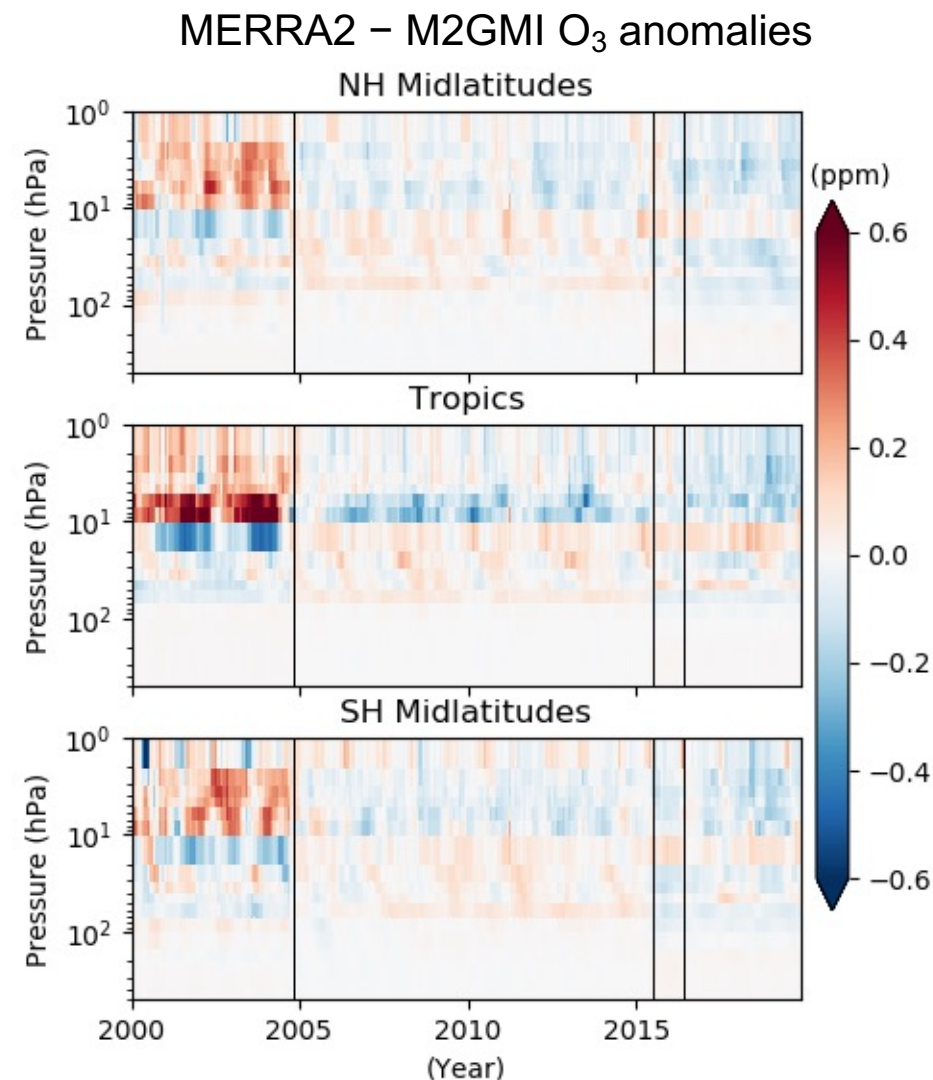
MERRA-2 and SAGE Ozone

- MERRA-2 independently validated using SAGE measurements
 - Agreement with SAGE II improves in 2005 (Wargan et al., 2017)
 - Well correlated with a slight low bias with respect to SAGE III/ISS solar occultation measurements
 - Preliminary comparisons to lunar occultation



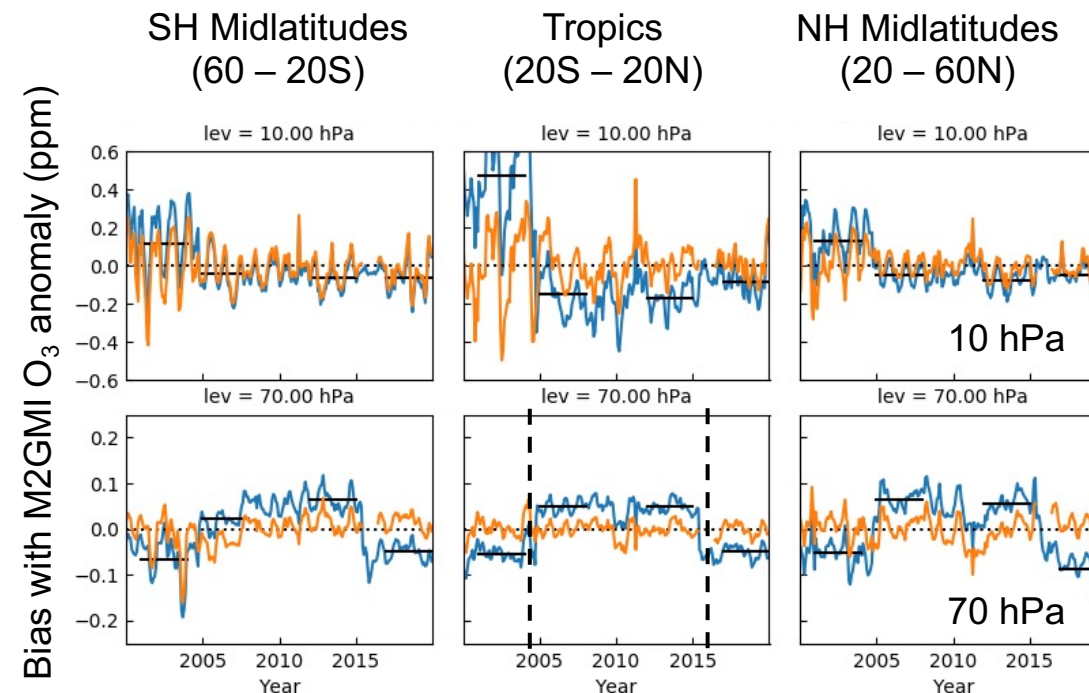
Aura era discontinuities

- Follow methods introduced by Wargan et al. (2018) to address discontinuities
 - **M2GMI**: Global Modeling Initiative (GMI) chemistry simulations using MERRA-2 meteorology
 - O₃ calculated within GMI (no ozone data assimilation)
- Updates to O₃ observation system introduce systematic biases
 - 2004: Inclusion of Aura MLS and OMI
 - 2015: Updates in MLS version
 - 2016: Turn off MLS assimilation in lower pressure levels



Aura era discontinuities

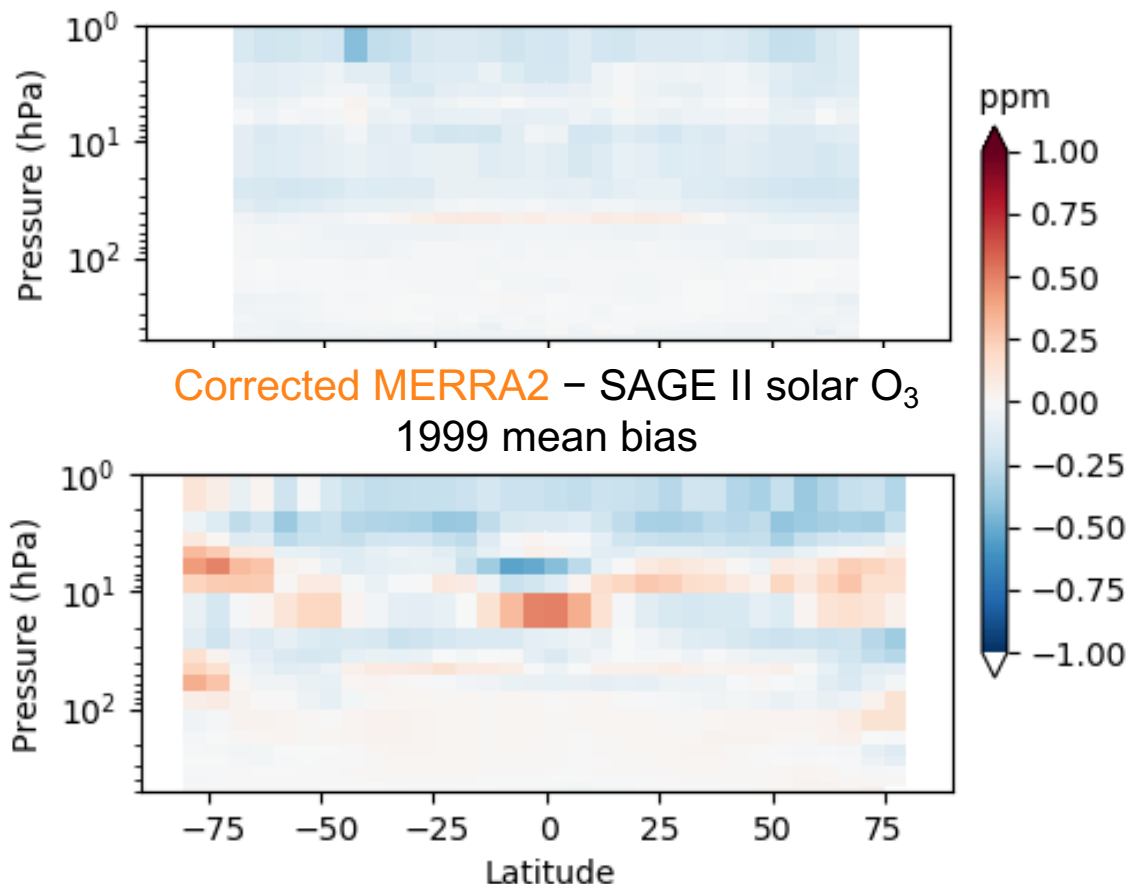
- Use M2GMI as a transfer function across each O₃ observing system update
 - Find the difference between **MERRA-2** and M2-GMI before and after updates
 - **Corrected MERRA-2** fields are stable with respect to M2GMI
 - Able to reproduce and extend findings of Wargan et al. (2018)



Aura era discontinuities

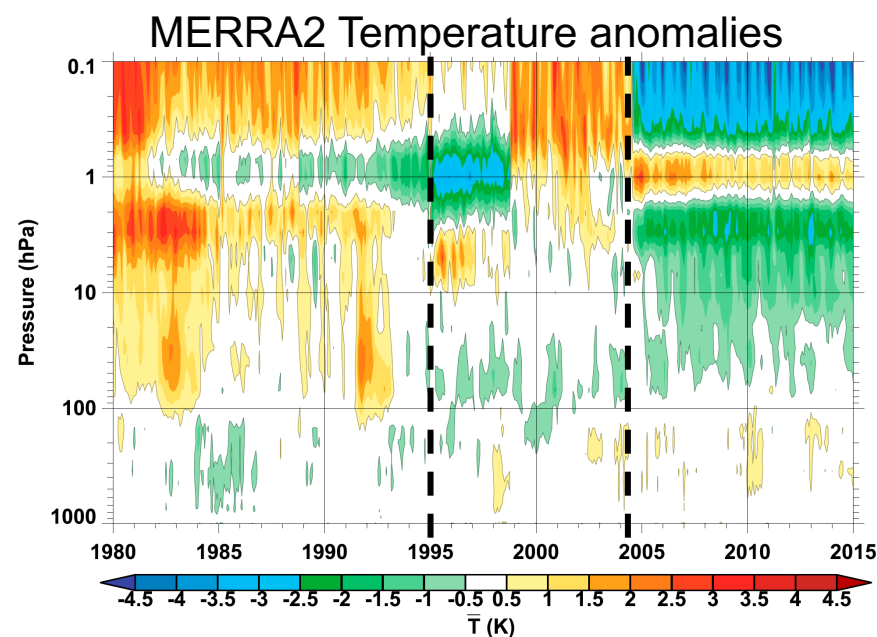
- Use M2GMI as a transfer function across each O₃ observing system update
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 - **Corrected MERRA-2** fields are stable with respect to M2GMI
 - Able to reproduce and extend findings of Wargan et al. (2018)
- Extend corrected MERRA-2 record to pre-Aura
 - Preliminary comparisons to SAGE II
 - MERRA-2 meteorological updates in 1998 and 1995

MERRA2 – SAGE III/ISS solar O₃
2018 mean bias



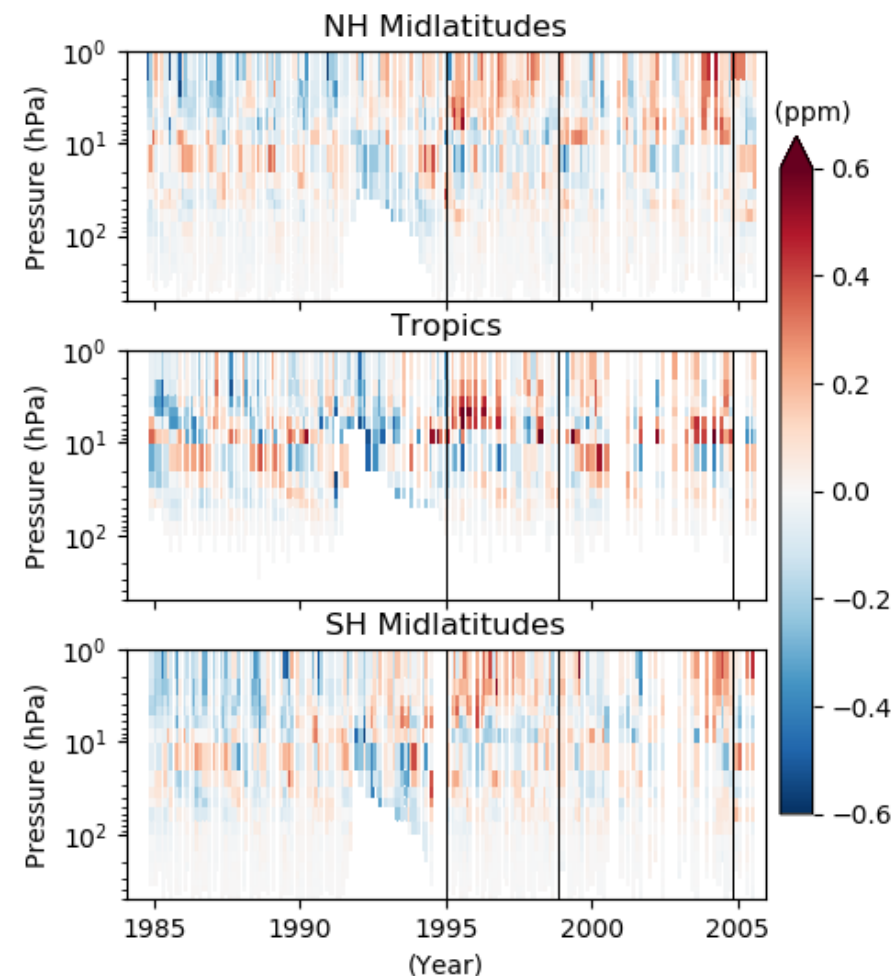
SAGE II era discontinuities

- Evaluate impact of temperature discontinuities on MERRA-2 ozone fields
 - Potential to impact M2-GMI O₃ via meteorology
 - Use SAGE II record as a transfer function



Gelaro et al. (2017)

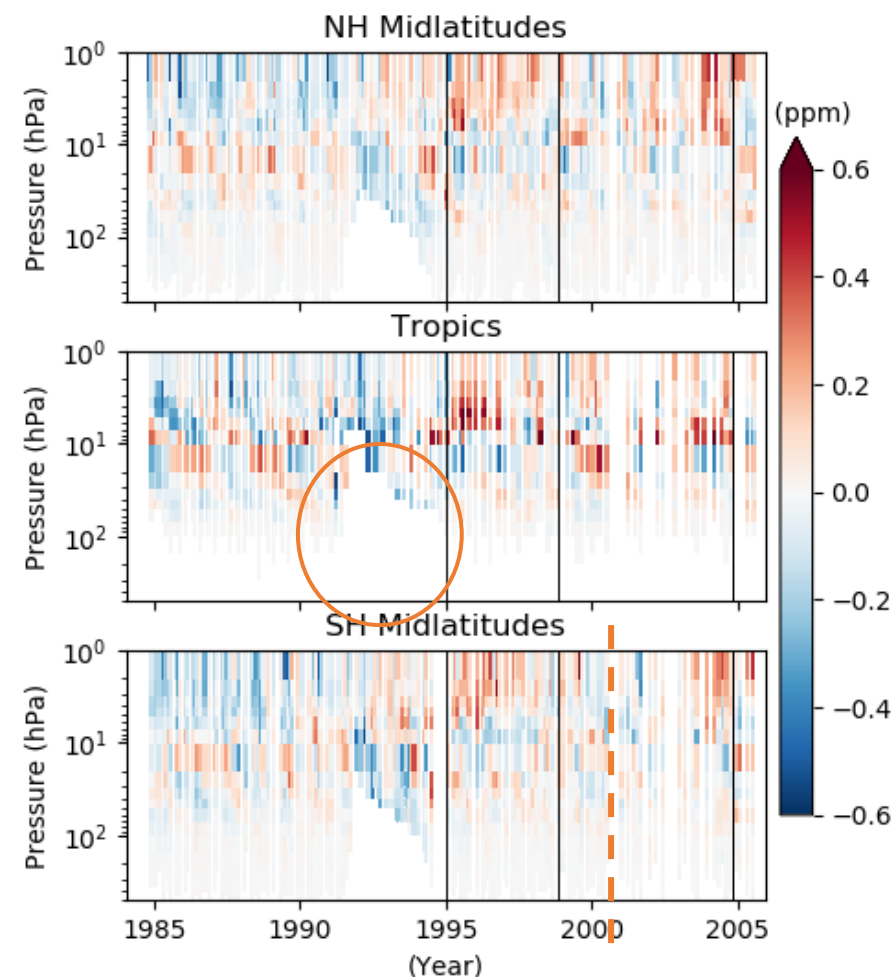
MERRA2 – SAGE II sunrise O₃ anomalies



SAGE II era discontinuities

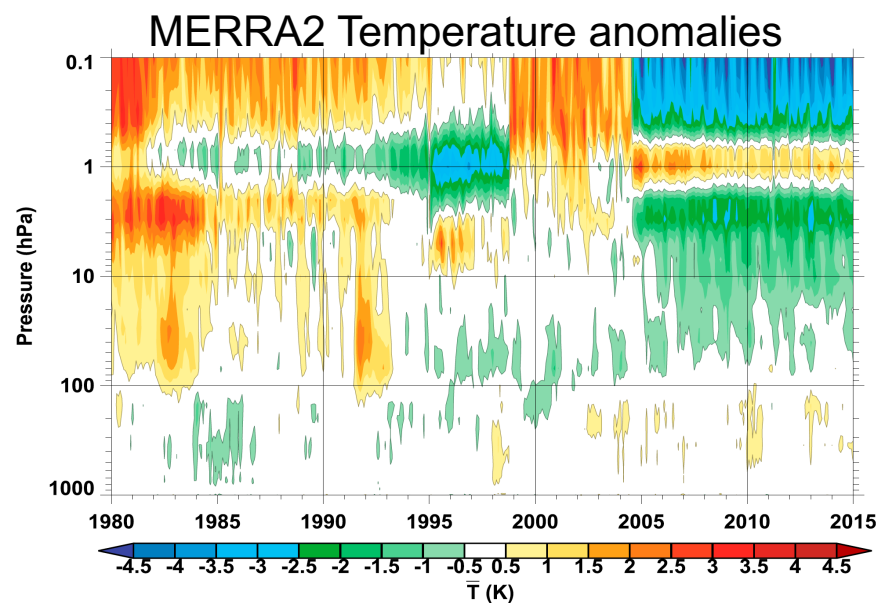
- Evaluate impact of temperature discontinuities on MERRA-2 ozone fields
 - Potential to impact M2-GMI O₃ via meteorology
 - Use SAGE II record as a transfer function
- Prior to 1995 meteorological update:
 - Interferences from 1991 Pinatubo eruption
 - Additional loss of SAGE II data in 1993/1994
- Following 1998 update:
 - SAGE II outage in 2000, returns at half sampling (2001 – 2005)

MERRA2 – SAGE II sunrise O₃ anomalies



Future Directions

- Continue to evaluate impact of temperature discontinuities on MERRA-2 O₃
 - Sensitivity of trends to bias correction across 1998 update
 - Determine pressure levels impacted by 1995 update
 - Impact on the 2004 M2GMI correction



Gelaro et al. (2017)

MERRA2 – SAGE II sunrise O₃ anomalies

